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LIGHTWEIGHT PHOTOVOLTAICS

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1 INTRODUCTION

Lightweight structures and Photovoltaic are two elements in the building industry with hardly any relations to each other. Beside the rigid silicon based panels a new generation of thin and flexible panels will be ready for the market and will present useful qualities for tensile applications.

One of the main targets of tensile structures is the minimization of the materials used in their construction. It is my intention to combine this ecological factor with one of the biggest challenge of today: generating energy with consideration for our environmental responsibility. To build ambitious and mass reduced architecture with intelligent engineering and smart power generation.

2 PHOTOVOLTAIC TECHNOLOGIES TODAY

2.1 What are Photovoltaics?

Generally Photovoltaics (PV) means the technology of generating electrical power by converting solar radiation into direct current electricity by using solar cells to convert energy from the sun into a flow of electrons.

Today the majority of photovoltaic modules are used for grid connected power generation. An inverter is required to convert the DC to AC. Beside that off-grid applications are used to power small electronical equipment or to recharge batteries. Solar power is pollution-free during use.

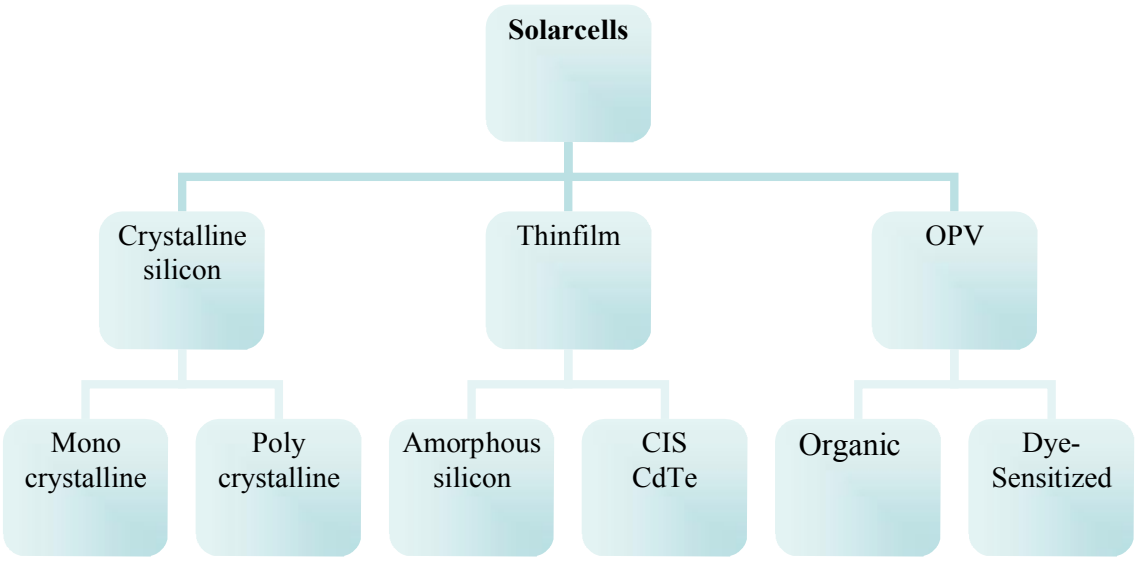
Apart from thin-film modules, silicon cells and modules represent by far the largest

segment of solar cells and modules available on the market.

2.2 What different types of materials and systems are available?

Several materials with different qualities and efficiencies are used today for photovoltaics:

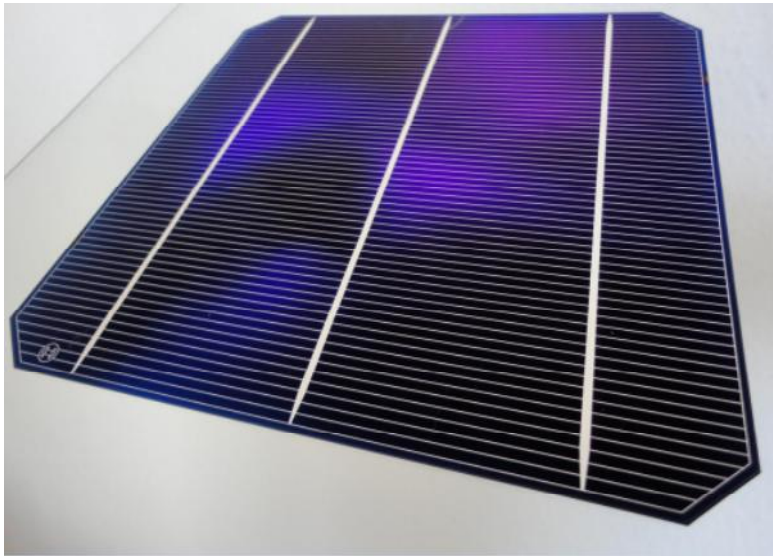
- Monocrystalline silicon
- Polycrystalline silicon
- Thin-film
- Amorphous silicon
- Cadmium telluride, and copper indium selenide/sulfide.
- Organic Photovoltaics (named as the "Third generation" in PV)
- Other systems with small value for the actual markets



Technology	Encapsulation	Weight
crystalline	glass	heavy
Thin-film	glass/PET foil	heavy/light
OPV	PET foils/ETFE foils	light

Crystalline wafers are mainly encapsulated in glass to stabilize their fragile structure. The silicon for thin-film modules is evaporated on glass or sometimes on PET. Both, crystalline and thin-film modules are not very useful in applications regarding lightweight and pliability.

3 CRYSTALLINE SILICON TECHNOLOGY



Very thin and shock-sensitive Wafer with mono-crystalline Silicon Technology by BOSCH®

These amorphic Silicon plates, called “Wafer” are very sensitive to any loads and need also to be covered with solid glass to avoid any contact with water or even air moisture.

A solar module is made of an array of solar cells (a panels with 60 cells is standard) encapsulated in glass and water- and weather-proof foils stabilized by a ridged aluminum frame.

These modules are heavy and need to be mounted to a riged steel structure on a certain angle towards the sun-position at noon, when the sun has the best light emission.

4 FLEXIBLE PHOTOVOLTAIC MATERIALS

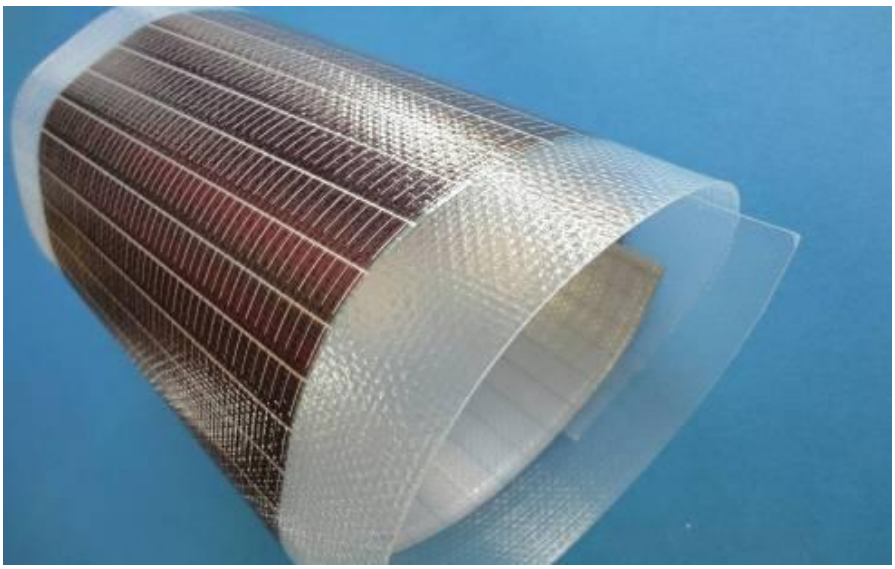
Some of the various technologies are able to be used on flexible and less shock-sensitive solar panels. This allows them to be used on irregular curved surfaces of tensile membrane or cable structures.

Less information is available concerning the strength of the panels: how they will react under tension load with panel capacity while still generating power.

Global Solar® Copper Indium Gallium DiSelinide (CIGS) thin film solar material

Global Solar Energy has evolved into a major producer of thin-film photovoltaic Copper Indium Gallium DiSelenide (CIGS) solar cells. Global Solar is the leading manufacturer of CIGS thin-film solar on a flexible substrate.

These panels are developed for direct on-roof installation



Flexcell® Module with flexible amorphous Silicon (aSi) Thin Film Technology

Flexcell manufactures flexible PV modules using amorphous silicon ("a-Si"), which has various advantages over glass-based modules: lower material cost per Watt peak ("Wp"), wider application versatility. Beside direct-on-roof applications other uses are possible:

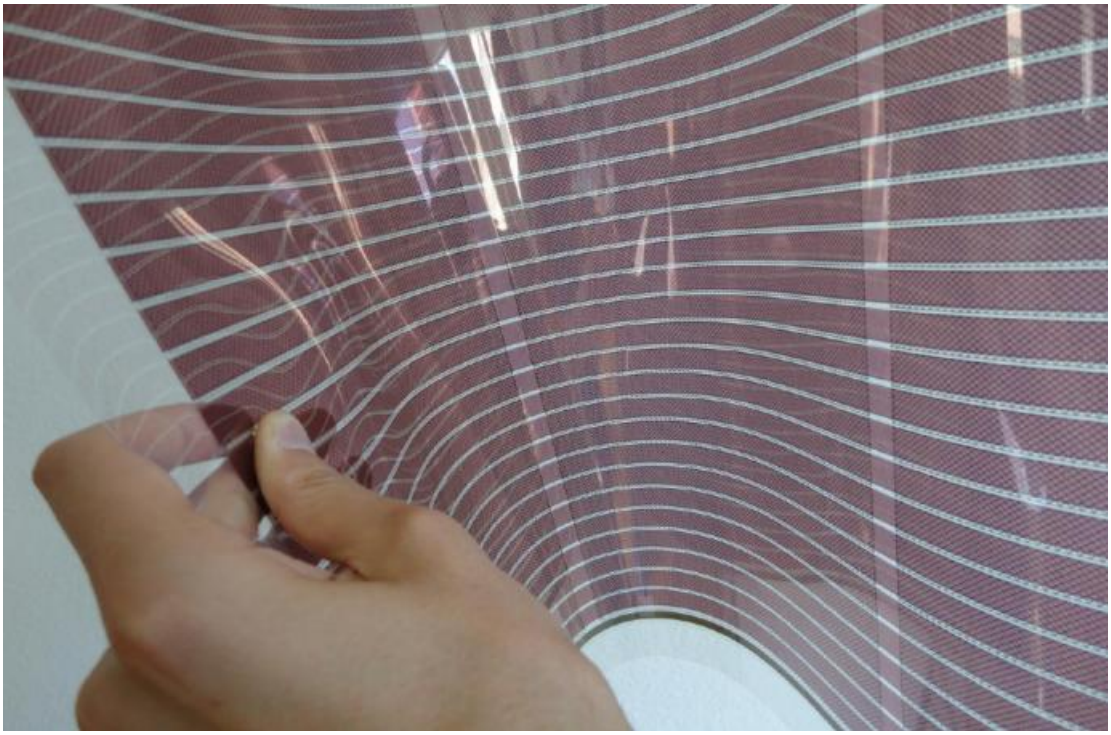
Ackermann + Partner, Munich, AMW Carport Munich, under construction.

In this roof application the solar panels are installed to the ETFE foil cushions fixed on the internal layer: generating shade and energy.

Scientists at Empa, the Swiss Federal Laboratories for Materials Science and Technology, have improved on their previous flexible solar cell and achieved an efficiency of 18.7 percent.

Flexible copper indium gallium selenide or C.I.G.S. solar cells are still an emerging field. But a team of scientists, led by Ayodhya N. Tiwari, have worked to improve the material's efficiency.

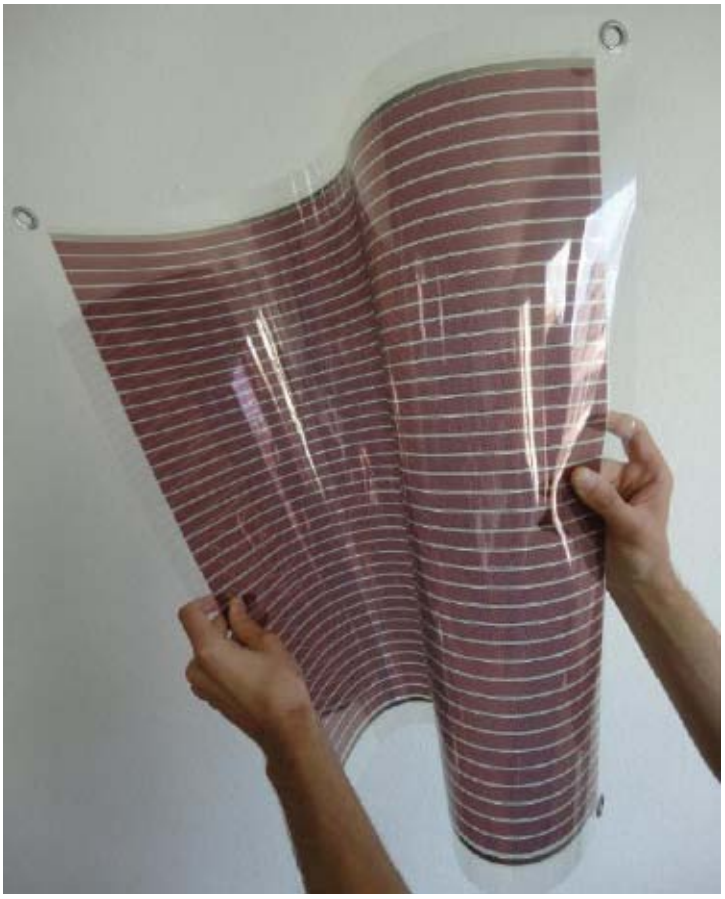
5 ORGANIC PHOTOVOLTAICS (OPV)



Semi-transparent and flexible POWER Plastic® Solar module from KONARKA®

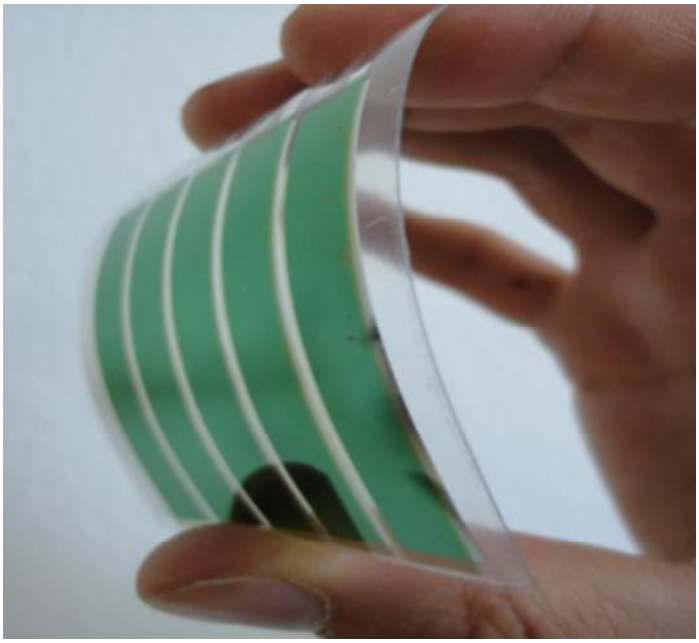
Organic Photovoltaics (OPV) is a complete new technology in the photovoltaic industry and is beginning to be used commercially as the third generation in photovoltaic development. In contrast to silicon-based solar panels here the photo-reactive layer is based on (organic) carbon polymer. These thin and flexible solar panels will allow completely new uses and applications.

Together with the ability of generating power, the tensile OPV structures will be of evident environmental importance for our future.



OPV meets the basic targets of light weight structures: mass minimization:

1. Less than 1 gramm of the power-generating polymer material is necessary to produce one square meter of a solar panel.
2. The printing or vacuum-deposition process needs less energy and production temperature and makes OPV a sustainable product.
3. Less weight and transportation volume make OPV also easy to handle and transportation
4. The optical absorption coefficient of organic molecules is high, so a large amount of light can be absorbed with a small amount of materials.

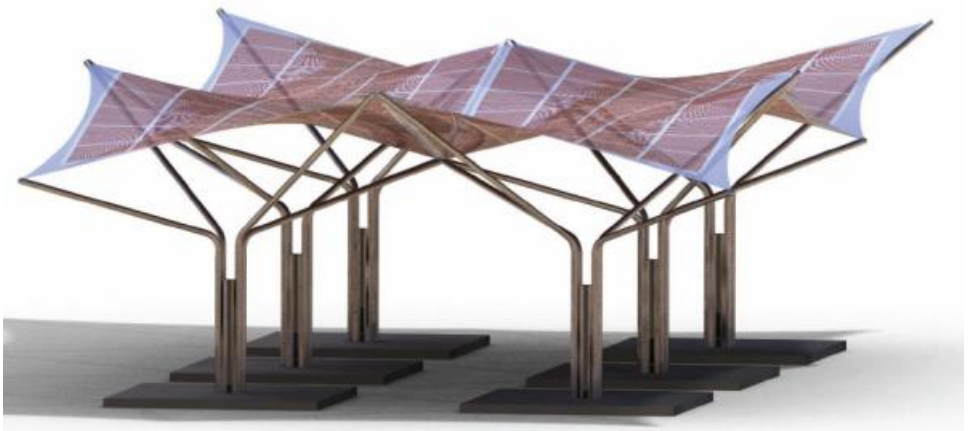


Heliathek® Panel with flexible Organic PV based on vacuum-deposited small molecules

A photovoltaic cell is a specialized semiconductor diode that converts visible light into direct current. Organic photovoltaics (OPV) does so using organic molecules as light absorbers. These organic materials are engineered to have the correct band gaps to absorb most of the solar energy. The field of OPV has two main branches, the route of vacuum-deposited small molecules, and the route of usually wet-printed polymers.

Heliatek is a technological leader of vacuum-deposited small molecule OPV. First products ready for the market are expected end of 2012.

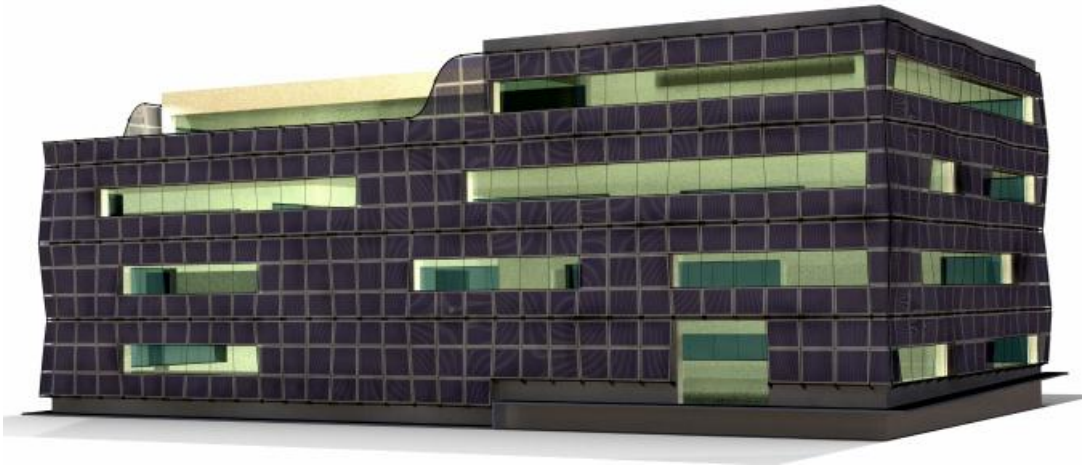
6 APPLICATIONS WITH OPV



Lightweight Photovoltaic tensile roof by Solartension® for SIEMENS outdoor working space

Tensile Structures using OPV Modules for a Solar Roof, designed by Solartension

Organic solar cells will achieve very low production costs when produced in high volumes, since they require only very small amounts of material. The production processes require less energy and thus lead to a significantly reduced energy payback time.



Tensile OPV façade for GREEN BUILDING VIS® in Hörbranz, Austria by Solartension

Vertical Solar sail at INTERSOLAR fair booth of LAPP group by Solartension

SOLARTENSION detail with structural and electrical cable connections